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What is known about the germination of herbaceous-shrub species from open wetlands in the Cerrado?

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O que se sabe sobre a germinação de espécies herbáceo-arbustivas de áreas úmidas abertas no Cerrado?

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Resumo

As áreas úmidas aberta do Cerrado são compostas predominantemente por vegetação herbáceo graminóide sob solos úmidos, ácidos, e ricos em matéria orgânica. Sua dinâmica hidrológica sustenta elevada riqueza de plantas adaptadas às condições de flutuação do lençol freático devido a sazonalidade hídrica. Este estudo realizou uma revisão da literatura para avaliar o conhecimento sobre germinação, viabilidade, armazenamento e dormência das espécies mais abundantes nas áreas úmidas abertas do Cerrado, visando identificar o conhecimento disponível para as iniciativas de restauração. Em 33 sítios amplamente distribuídos no Cerrado levantamos 192 espécies abundantes, distribuídas em 36 famílias. A maioria dessas espécies (63%) ocorrem em apenas um sítio, mostrando uma distribuição restrita das espécies abundantes. Os dados relacionados à germinação e viabilidade de sementes foram encontrados em apenas 46 espécies (~24%). Dessas 46 espécies, 45 apresentaram dados de germinação em laboratório e 11 foram avaliadas quanto à germinação no campo. Apesar do número limitado de espécies com dados disponíveis sobre taxas de germinação, viabilidade, dormência e armazenamento de sementes, os resultados obtidos indicam grande potencial dessas espécies herbáceas e arbustivas para a restauração, sendo características ecológicas que podem contribuir com o estabelecimento das espécies. Em 2023, apenas 12 espécies foram comercializadas pelas Redes de Sementes, das 192 levantadas nesse estudo. Nenhuma das 192 espécies está incluída no Registro Nacional de Cultivares do Ministério da Agricultura do Brasil. A restauração das áreas úmidas abertas do Cerrado enfrenta desafios, como a disponibilidade limitada de sementes nativas herbáceo-arbustivas no mercado e falta de conhecimento das características ecológicas das espécies, o que compromete o sucesso dos projetos de restauração.

Palavras chaves: comercialização de sementes, conservação, dormência, sementes, restauração, viabilidade

Abstract

The open wetlands of the Cerrado are composed of herbaceous graminoid vegetation under moist, acidic soils rich in organic matter. Their hydrological dynamics support a high richness of plants adapted to the fluctuating conditions of the water table due to seasonal water levels. This study carried out a literature review to assess the knowledge on germination, viability, storage and dormancy of the most abundant species in the open wetlands of the Cerrado, with the aim of identifying the knowledge available for restoration initiatives. In 33 widely distributed sites in the Cerrado, we surveyed 192 abundant species, distributed in 36 families. Most of these species (63%) occur on just one site, showing a restricted distribution of abundant species. Data related to seed germination and viability were found for only 46 species (~24%). Of these 46 species, 45 presented germination data in the laboratory and 11 were evaluated for germination in the field. Despite the limited number of species with available data on germination rates, viability, dormancy and seed storage, the results obtained indicate great potential of these herbaceous and shrub species for restoration, being ecological characteristics that can contribute to the establishment of species. In 2023, only 12 species were marketed by the Seed Networks, out of the 192 surveyed in this study. None of the 192 species are included in the Brazilian Ministry of Agriculture's National Register of Cultivars. The restoration of the wet grassland Cerrado faces challenges, such as the limited availability of native herbaceous and shrub seeds on the market and a lack of knowledge about the ecological characteristics of the species, which compromises the success of restoration projects.

Keywords: seed marketing, conservation, dormancy, seeds, restoration, viability

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Introdução geral

Ocupando 200 milhões de hectares do território brasileiro o Cerrado já teve 50% da sua área nativa do Cerrado convertida em zonas urbanas, pastagens e monoculturas (Alencar et al. 2020). O cerrado abriga oito das 12 principais bacias hidrográficas brasileiras, incluindo as cabeceiras de importantes rios brasileiros como São Francisco, Tocantins-Araguaia e Paraná, que alimentam bacias nacionais e internacionais e estão sob pressão o desmatamento (Rodrigues et al. 2022).

No Cerrado as vegetações abertas úmidas são classificadas em Veredas, Campos Limpos Úmidos, Campos Sujos Úmidos e Campos com Murundus. São áreas de extrema importância para a conservação da água, como também sustentam uma flora e fauna endêmicas deste ambiente (Durigan et al. 2022). As áreas úmidas apresentam composição florística, estrutura e dinâmica na comunidade que favorecem serviços ecossistêmicos únicos, por exemplo, a regulação dos regimes hídricos e papéis sociais para as comunidades rurais (Meirelles et al. 2002; Junk et al. 2014; Durigan et al. 2022). As áreas conservadas no Cerrado Brasileiro estão cada vez mais fragmentadas, causando a perda da biodiversidade e outras consequências ambientais como a mudança no regime de fogo e a escassez do recurso hídrico (Rodrigues et al. 2022).

As áreas úmidas ocupam, aproximadamente, 20% do território, porém existe ainda a necessidade de compilação de dados sobre o conhecimento ecológico de áreas úmidas no Brasil, principalmente no Cerrado (Junk et al. 2014; Bozelli et al. 2018). A degradação desses ambientes pode levar ao colapso do ecossistema, sendo um elemento importante diante das catástrofes que estão ocorrendo, combinando com a diminuição da diversidade que esse ambiente sustenta (Salimi et al. 2021). Diante das variações que ocorrem nos tipos de área úmidas e sua biodiversidade, e da perda acelerada desse ambiente por degradação, principalmente a perda do estrato herbáceo-arbustiva, ressalta-se a importância de estudos relacionados à restauração e conservação desses ambientes (Durigan et al. 2022).

Para minimizar os danos aos ecossistemas naturais a ONU em 2014, na Convenção sobre Diversidade Biológica, cria a "Década das Nações Unidas para a Restauração do Ecossistema", chamada Agenda 20-30. Tal iniciativa tem como objetivo restaurar 350 milhões de hectares até 2030, para manter e proporcionar os serviços ecossistêmicos perdidos em consequência da perda da biodiversidade e amortecer os efeitos negativos da degradação de ambientes naturais (Urzedo et al. 2020). No entanto, suas ações estão relacionadas a ambientes florestais, incentivando o plantio exclusivo de espécies arbóreas de forma exacerbada (Buisson et al. 2019). Somado a isso, no Acordo de Paris, a International Union for Conservation of Nature (IUCN) e o World Resources Institute (WRI), criaram o acordo do Desafio de Bonn, no qual o Brasil se responsabilizou em restaurar 12 milhões de hectares até 2030 que estão previstos no Plano Nacional de Recuperação da Vegetação (Dudley et al. 2020; Brasil 2017).

A década da restauração representa uma grande oportunidade de recuperar sistemas degradados em áreas que possam tornar-se produtivas promovendo serviços ecossistêmicos, porém é necessário atenção aos riscos, como por exemplo a homogeneização da paisagem. Devido à falta de conhecimento elaborado em torno da restauração ecológica, na qual tem o objetivo de promover a recuperação de áreas degradadas através da incorporação da vegetação nativa, e promoção da manutenção da biodiversidade, em alguns projetos de restauração acabam fracassando em seus objetivos. Nesse sentido, incentivos ecológicos e socioeconômicos em defesa da restauração de campos e savanas dão início a construção de conhecimentos e capacidades para o sucesso da restauração de ambientes não florestais (Dudley et al. 2020). A política que impulsiona a restauração de áreas úmidas na América do Norte é a lei de proteção das águas limpas de 1972, uma das leis mais antigas do mundo que exige que as perdas permitidas de zonas úmidas sejam aliviadas através da criação ou restauração dessas áreas, impulsionando o mercado de venda e compra de créditos no país para a mitigação climática. No Brasil, a assinatura na Convenção de Ramsar de 1993 impulsionou o início das pesquisas direcionadas a ecologia de conservação e delineamentos para a construção de uma política de proteção de áreas úmidas.

As agendas de conservação e restauração dos trópicos devem atentar-se aos ecossistemas de campos e savanas, que cobrem 1/3 da terra, necessitando de esforços de restauração tão urgentes quanto os ecossistemas florestais (Buisson et al. 2021). O desmatamento acelerado no Cerrado, demanda de compreensão do seu sistema ecológico e de técnicas eficazes para restauração de suas fitofisionomias abertas (Pilon et al. 2023). Para a restauração de áreas úmidas abertas do cerrado, além de reconhecer suas espécies é importante também conhecer a germinabilidade e biologia de suas sementes.

O conhecimento sobre a dormência, que é o mecanismo que controla o início do processo de germinação das espécies é uma informação relevante para a germinação das espécies em campo na restauração ecológica. A partir do manejo e o conhecimento sobre dormência das sementes, pode ser utilizado para montar estratégia de inserção das espécies na restauração ecológica, (Kolb et al. 2016; Escobar et al. 2018), contribuindo também com a tomada de decisão sobre a forma e período de armazenamento adequado para cada espécies.

As leis, regras e testes aplicados para sementes agrícolas são bem conhecidos, principalmente na portaria nº 142 de 27/11/1996 – Credenciamento do LASP/das pelo Ministério da Agricultura. A Lei 10.711/03 é base para a comercialização de sementes e mudas no Brasil, a Instrução Normativa 17 de 2017, juntamente com o decreto 10.586 de 2020 e a Portaria MAPA 538 de 2022, que regulariza, credencia e certifica o serviço de comercialização de sementes e mudas, de forma a seguir a Regras de Análise de Sementes (RAS) e a ABNT. A realização de testes de análise de pureza, germinação/ viabilidade das sementes que requerem um alto investimento de recursos, existem poucos laboratórios credenciados, causando um distanciamento maior entre as Redes de coleta de sementes e os laboratórios credenciados no MAPA (Celentano et al. 2023). Diante este cenário, as vezes os resultados não chegam antes da implementação do projeto de restauração. As sementes das espécies nativas do Cerrado apresentam uma alta variabilidade interespecíficas e complexidade morfológica e fisiológicas que não se encaixam na RAS, dificultando a apresentação de um boletim de análise da semente.

Diante da demanda de restauração das áreas campestres úmidas do Cerrado, esse estudo de revisão bibliográfica teve como objetivo contribuir com a construção de conhecimento sobre a germinação, dormência e viabilidade das sementes de espécies típicas de áreas úmidas abertas no Cerrado.

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Introduction

In order to successfully restore open wet grasslands in the Cerrado, it is important to have an understanding of the species present and to assess their characteristics in terms of germination and establishment, contributing to the maintenance of diversity and ecosystem services and more effective conservation strategies for open wet grassland (Holl et al. 2000; Kolb et al. 2016; Pilon et al. 2023). However, it is challenging to find native species on the market that possess the ideal characteristics for wet grasslands (Pilon et al. 2023). Currently, there is a plethora of native tree species being marketed, predominantly abundant and generalist species from the Cerrado, with few species prescribed by vegetation type (Frischie et al. 2020). Despite advances in the use and commercialization of native Cerrado herbaceous-shrub seeds, there is still a dearth of knowledge about the biology and ecology of these species (Schmidt et al. 2019; Pilon et al. 2023). An understanding of the characteristics of open wet grassland species, their ecology, and seed biology is essential for the effective planning of restoration actions in the Cerrado, which depend on a supply of seeds in sufficient quantity and quality (Aires et al. 2014; Pilon et al. 2023).

Tropical savannas and grasslands are ancient and diverse ecosystems, composed predominantly of herbaceous-shrub vegetation (Veldman et al. 2015; Overbeck et al. 2022). The Cerrado, the largest mesic savanna, is characterized by a diversity of vegetation types, species and life forms, which collectively form a complex vegetational mosaic in the landscape (Ribeiro & Walter 2008). The wetlands of the Cerrado are of great importance for water conservation, providing water directly to eight of Brazil's 12 main river basins (Lima & Silva 2008). These include the headwaters of important rivers such as the São Francisco, Tocantins-Araguaia and Paraná, which are under pressure from deforestation (Rodrigues et al. 2022). These humid vegetations occur over a wide climatic, altitudinal, edaphic, and hydrological range throughout the Cerrado, supporting a high diversity of plant species that are adapted to soil waterlogging conditions (Cianciaruso & Batalha 2009; Leite et al. 2018; Bijos et al. 2023). Wetlands in the Cerrado region typically occupy acidic soils with limited nutrient availability, high organic matter content, and a shallow water table (Souza et al. 2021; Bijos et al. 2023).

Wetlands contribute to the regulation, availability, and purification of water, as well as maintaining biodiversity, microclimate regulation, food availability for fauna, the development of ecotourism activities, and the way of life and culture for traditional communities (Chopra 2005; Greb et al. 2006; Schmidt et al. 2011; Buisson et al. 2021). The protection of wetlands and the implementation of ecological restoration policies can contribute to the mitigation of climate change and carbon emissions, thereby strengthening the economy based on nature conservation (Dudley et al. 2020).The diversity of wetland types, their rich biodiversity, and the accelerated degradation of this environment, especially the loss of the herbaceous-shrub layer, underscore the significance of studies aimed at restoring and conserving these environments (Durigan et al. 2022). It is imperative that conservation and restoration agendas in the tropics consider grassland and savannah ecosystems, which collectively cover a third of the earth and require restoration efforts that are as urgent as those for forest ecosystems (Buisson et al. 2019). The accelerated deforestation in the Cerrado necessitates an understanding of its ecological system and the development of effective techniques for restoring its open vegetation (Pilon et al. 2023). In order to minimize damage to natural ecosystems, the United Nations (UN) launched the "United Nations Decade for Ecosystem Restoration" (Agenda 20-30) in 2014 during the Convention on Biological Diversity. This initiative aims to restore 350 million hectares by 2030 to re-establish ecosystem services and mitigate the negative effects of environmental degradation (Urzedo et al. 2020). These initiatives aim to enhance the recovery of degraded areas through the provision of support to landowners, thereby conferring benefits to the entire Brazilian population (Brasil 2017). However, these actions tend to prioritize the restoration of forest environments over open ecosystems, as a means of reducing greenhouse gas emissions. It is recommended that herbaceous-shrub vegetation of open wetlands be incorporated into restoration techniques, as they possess specific ecological functions for maintaining these ecosystems and have adapted to their environmental conditions (Buisson et al. 2021). Moreover, it is recommended that between 60% and 80% of the species that comprise grassland and savannah communities be utilized in restoration programs to maintain ecosystem services (Schmidt et al. 2019), these species promote water conservation and carbon storage in the soil, through herbaceous and shrubby vegetation, as well as the maintenance of traditional communities and peoples who live off natural resources from open ecosystems as well as promoting the conservation of these environments (Durigan et al. 2020).

Knowledge about dormancy, which is the mechanism that controls the start of the germination process of species, is relevant information for the germination of species in the field in ecological restoration. Management and knowledge of seed dormancy can be used to develop a strategy for the insertion of species in ecological restoration (Kolb et al. 2016; Escobar et al. 2018), as well as contributing to decision-making on the appropriate form and storage period for each species. All these variables are important for decision-making when selecting species for ecological restoration (Pilon et al. 2023).

A literature search was carried out to identify the most abundant species of open wet grasslands in the Cerrado and to find out about their germination characteristics and commercial availability. Considering the pressing need to restore open wet grasslands in the Cerrado, this study aimed to address the following questions through a comprehensive literature review: 1. What are the most abundant herbaceous-shrub vegetation in open wet grasslands in the Cerrado? 2. What is the state of knowledge in the literature on the germination, dormancy, viability, and storage capacity of the seeds of these species? 3) Which abundant open wetland species are included in the seed analysis rules? 4) Which abundant open wetland species are currently being marketed?

Materials and methods

We searched the literature for studies on open wet grasslands in the Cerrado biome. are ancient and diverse ecosystems, composed of a layer of herbaceous and shrubby vegetation (Veldman et al. 2015; Overbeck et al. 2022). Occurring in Central Brazil in patches of open vegetation on moist soil, they are classified as Veredas, Campos Limpos úmidos, Campos Sujos Úmidos, and Campos Sujos. The climate of the region is tropical seasonal AW according to the Köppen classification (Alvares et al. 2013), with two well-defined seasons, a rainy summer from October to May and a dry winter from June to September. The soils are predominantly Ferralsols, described as acidic, mesotrophic and dystrophic (Reatto et al. 2008).

To ascertain the most abundant species (coverage or density) in open wetlands of the Cerrado, a bibliographic search was conducted using the search platforms The Web of Science Core Collection and Google Scholar from 2022 to March 2024. The searches were conducted in both English and Portuguese, using a combination of the following terms: "*campo limpo úmido*"/ "moist grassland"/ "wet grassland"; "*campo sujo úmido*"/ "moist shurbgrassland"; "wet shrubby grassland"; "campo de murundus"/ "*murundus* field"; "earth mound grassland"; "*vereda*"/ "palm swamp"; "*mauritia flexuosa*"; "Cerrado"; "abundance"/ "*abundância*", "cover"/ "*cobertura*", "density"/ "*densidade*"; "*composição florística*", "floristic"; "*fitossociologia*"/ "phytosociology". The terms were based on the phytophysiognomies of the Cerrado, as described by Ribeiro and Walter (2008) and Durigan et al. (2022). The selection criterion targeted articles that presented abundance data, such as relative cover and/or relative density of species in humid open physiognomies. In addition, the articles found were grouped together on the Zotero platform, with no date limitation for this survey.

The research findings were derived from the physiognomies of interest, with the species collectively accounting for 80% of the abundance per site. This was based on Grime's Theory, which states that the most abundant species control ecological processes (Grime 1998; Pérez-Harguindeguy et al. 2013). Once the searches and sorting had been completed, the bibliographic references, scientific names of the species, families, states, municipalities, geographical coordinates, abundance values, physiognomies, and sampling methods were extracted from the scientific papers and compiled in an Excel spreadsheet. The nomenclature of the families, genera, and species was standardized using the Flora e Funga do Brasil (2024) databases, in the 'flora' package (version 0.3.4; Carvalho 2020) of the R program (version 3.6.2; R Core Team 2019).

Subsequently, with the list of the most abundant species, literature searches were carried out for articles that provided results related to the percentage germination, germination time, storage time, seed viability and dormancy of the species. These results were accessed from the "web of Science" and "google scholar" databases, where a search was carried out for each species. Searches were carried out combining the name of the species with the following terms: "*germinação"*/"germination"; *"reprodução"*/"reproduction"; *"semente"*/"seed"; *"características"*/"trait"; *"dormência"*/"dormancy"; *"temperature"*/"temperature"; *"viabilidade",* "seedling", "development"; *"seed viability"*. The information was organized in an Excel spreadsheet.

The data was organized and compiled according to the following categories: laboratory germination, non-laboratory germination, germination with storage for 6-12 months, germination with storage for up to 12 months, average germination time, and seed viability without and with storage and dormancy.

In addition, we sought to identify studies that presented results for Cerrado wetland species that complied with the Seed Analysis Rules (RAS: *Regras de Análise de Sementes*) (Brasil 2009). The tests outlined in the RAS include purity analysis, germination testing, a tetrazolium test to assess seed viability, and moisture content analysis. This information is fundamental for the decision-making process regarding the use of seeds in planting techniques, irrespective of their intended purpose.

To assess the availability of seeds of species abundant in Cerrado wetlands, we consulted the list of species available for sale in November 2023, compiled by the companies Verde Novo (https://consultoriaverdenovo.weebly.com/), Rede de Sementes do Xingu (https://www.sementesdoxingu.org.br/) and Rede de Sementes do Cerrado (https://www.rsc.org.br/). These companies represent the primary market for native Cerrado seeds. In addition, the National Register of Cultivars (RNC: *Registro Nacional de Cultivares*) (https://www.gov.br/agricultura/pt-br/assuntos/insumos-agropecuarios/insumos-agricolas/sementes-e-mudas/producao-de-sementes-e-mudas), a document overseen by the Ministry of Agriculture, Livestock and Supply (MAPA: *Ministério da Agricultura, Pecuária e Abastecimento*) and Law No. 10.711, was consulted, which presents a protocol for the analysis of seeds of species that have been regularized for commercialization.

Results

A search of the literature yielded nine papers (Table S1) that presented data on the coverage and density of species in open wetlands, with 33 sites in the Cerrado (Fig. 1) with a total of 192 species were recorded. These species were the most abundant in the *campo limpo úmido*, *campo sujo úmido*, and *veredas*. The species are distributed across 36 families, with the most representative being Poaceae (62 species), Cyperaceae (28), Eriocaulaceae (19), Melastomataceae (14), Xyridaceae (12), Asteraceae (8), and Fabaceae (7) (Table S2).

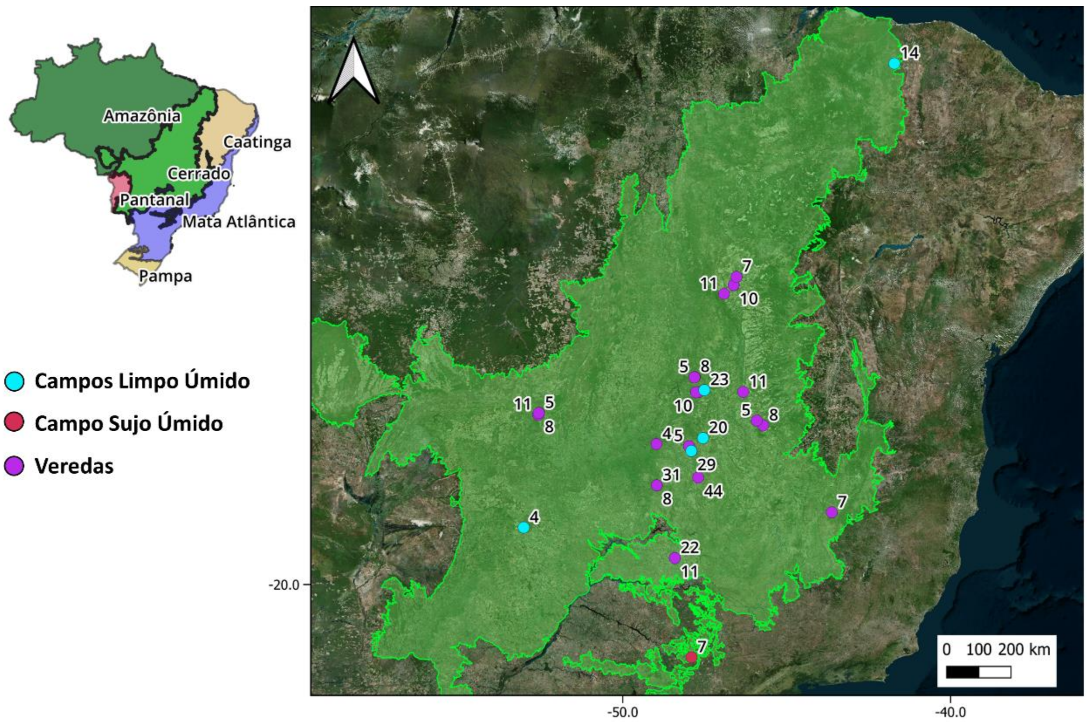

Figure 1. Distribution of the 33 open wetland sites in the Cerrado with the number of most abundant species at each site.

A total of 192 abundant herbaceous-shrub species from the Cerrado open wetlands were documented in the papers. Of these, 121 species (63%) were observed on a single site for 80% of the abundance per site. This indicates that the species are not abundant on all sites and have a potential restricted local distribution. Most of the abundant species occurred in only a few sites, with only two species (*Rhynchospora globosa* and *Paspalum lineare*) being common in 20 sites (60%) of the 33 sites included in the nine studies. A total of ten abundant species were present these included *P. lineare*, *R. globosa*, *Andropogon virgatus*, *Trachypogon spicatus*, *Rhynchospora tenuis*, *Echinolaena inflexa*, *Lagenocarpus rigidus*, *Andropogon bicornis*, *Andropogon lateralis*, and *Andropogon leptostachyus* of the 33 open wetland sites.

The data related to seed germination and viability was found for only 46 species (~24%). Of the 46 species, 45 presented laboratory germination data and 11 were evaluated for germination in the field (Table 1; Table S1).

Table 1. Systematization of the germination and viability of the seeds of the most abundant species in open wetlands of the Cerrado found in the literature. Values in brackets represent the results after seed storage. Lab = laboratory, Germ. = Germination, na = not available, D = Dormancy. ND = not dormant.
To see the source articles the numbers corresponding to them are in Table S2.

Species	Number Article	Lab Germ. freshly collected (%)	Field/ Germ. freshly collected (%)	Germ. 6-12 months of storage (%)	Germ. > 12 months of storage (%)	Mean germ. time (with storage) (days)	Viability (with storage) (%)	Dormancy
Andropogon bicornis	19, 5, 16	7-27.2	0-8	21-71	na	16.9	13 (0)	ND
Andropogon lateralis	5	81	na	47-72	na	na	84 (55)	ND

Species	Number Article	Lab Germ. freshly collected (%)	Field/ Germ. freshly collected (%)	Germ. 6-12 months of storage (%)	Germ. > 12 months of storage (%)	Mean germ. time (with storage) (days)	Viability (with storage) (%)	Dormancy
Andropogon leucostachyus	1, 31, 26, 16, 14	2-90	0-18	2.2	0.7	2.41-17 (11)	60.6-90	na
Andropogon selloanus	19, 27	31	32-36	2-88	na	11-16.1	na	ND
Andropogon virgatus	14	1	7	24	na	20	na	na
Arthropogon villosus	27, 26	97	na	na	na	na	97	ND
Axonopus brasiliensis	1, 14	3.6	4	38.5	3.5	36 (14-23)	20	na
Axonopus pellitus	27	na	0	0-6	na	na	na	na
Bulbostylis paradoxa	10	55	na	na	na	na	60	ND
Cambessedesia hilariana	36	2.1	na	na	na	20.5	na	ND
Chaetogastra gracilis	20	51.4	na	na	na	na	29.5	na

Species	Number Article	Lab Germ. freshly collected (%)	Field/ Germ. freshly collected (%)	Germ. 6-12 months of storage (%)	Germ. > 12 months of storage (%)	Mean germ. time (with storage) (days)	Viability (with storage) (%)	Dormancy
Chamaecrista desvauxii	12, 3	13-71	na	na	na	9	na	D
Cyperus sesquiflorus	7	68	na	na	na	6.57	na	na
Echinolaena inflexa	1, 28, 27, 21, 13, 23, 26	0-57	0-8.3	2-85	21.2	5-19 (8.5-10)	0-97	D
Hyptis campestris	20	25.2	na	na	na	na	na	ND
Hyptis crenata	8	9	na	na	na	na	8	na
Lippia rotundifolia	25	35	na	40	na	na	na	D
Loudetiopsis chrysothrix	5, 14	0-45	4	75	na	na	69 (80)	D
Ludwigia nervosa	34	21	na	na	na	10	na	na
Miconia chamissois	30	90	na	na	na	na	na	ND

Species	Number Article	Lab Germ. freshly collected (%)	Field/ Germ. freshly collected (%)	Germ. 6-12 months of storage (%)	Germ. > 12 months of storage (%)	Mean germ. time (with storage) (days)	Viability (with storage) (%)	Dormancy
Paspalum cordatum	14	11	12	na	na	16.2	na	na
Paspalum erianthum	10	60	na	na	na	na	60	ND
Paspalum gardnerianum	1, 19, 27, 21, 23	3-45.2	0-19	30-55	na	6.6-17 (9- 12)	15.2	D
Paspalum hyalinum	14	3	5	na	na	15.5	na	na
Paspalum polyphyllum	26, 24, 31	3-40	na	na	na	9.3	3	na
Paspalum trichostomum	19	8	na	56	na	16.4	na	na
Piper aduncum	35	89.67	na	na	na	na	na	na
Rhynchospora barbata	17	0	na	na	na	na	na	na
Rhynchospora consanguinea	15	0	na	na	na	na	39.5	D

Species	Number Article	Lab Germ. freshly collected (%)	Field/ Germ. freshly collected (%)	Germ. 6-12 months of storage (%)	Germ. > 12 months of storage (%)	Mean germ. time (with storage) (days)	Viability (with storage) (%)	Dormancy
Rhynchospora rugosa	7	31	na	na	na	17.98	na	na
Saccharum angustifolium	6	45	na	na	na	na	na	na
Schizachyrium condensatum	18	33	na	na	na	na	na	na
Schizachyrium sanguineum	24, 23, 31, 21	40-100	na	na	na	7.1-13.7 (16.8)	80	na
Schizachyrium tenerum	31, 13	20-84	0	na	na	9.8-10.25	82-95	na
Setaria parviflora	19	46	na	25	36.5	6	na	na
Stylosanthes angustifolia	34	35.26	na	na	na	na	na	D
Syngonanthus anthemiflorus	22	90	na	na	na	na	na	na
Syngonanthus caulescens	22	20	na	na	na	na	na	na

Species	Number Article	Lab Germ. freshly collected (%)	Field/ Germ. freshly collected (%)	Germ. 6-12 months of storage (%)	Germ. > 12 months of storage (%)	Mean germ. time (with storage) (days)	Viability (with storage) (%)	Dormancy
Syngonanthus gracilis	22	70	na	na	na	na	na	na
Syngonanthus nitens	23, 8	85-88	na	na	na	15	80	na
Trachypogon spicatus	4, 20, 17	1-2.1	na	na	na	na	5.2	na
Trembleya parviflora	11	14-70	na	na	40	15	na	na
Tristachya leiostachya	1	11	na	25	na	25 (10-14)	21.8	na
Xyris hymenachne	9	76	na	na	na	na	3	na
Xyris jupicai	20	57.5	na	na	na	na	15.2	na
Xyris macrocephala	17	0	na	na	na	na	na	na

Germination data for 14 species stored for up to 12 months exhibited a percentage of germination, with values spanning from 0% to 88%. The germination exhibited a range of 0.7 to 40% for five species following storage periods exceeding 12 months. *A. bicornis* demonstrated an increase in viable seeds following storage, with 13% for 21% viability after storage. *A. lateralis* demonstrated a decrease in viable seeds following storage, with 84% for

76% viability after storage. Species such as *Andropogon leucostachyus* exhibited a range of seed viability values from 27% to 90% (Table 1).

We obtained the data for the mean germination time (MGT) for 22 species. The shortest MGT was 5 days for *E. inflexa*, and the longest MGT was 36 days for *A. brasiliensis.*

A total of 21 species exhibited data related to seed viability. This the literature revealed that seed viability values were below 10% for three species, between 11 and 30% for six species, and above 30% for 11 species. Notably, *Arthropogon villosus, Schizachyrium sanguineum*, and *Schizachyrium tenerum* exhibited values exceeding 80%.

We obtained seed dormancy data for 16 species, with nine species exhibiting no seed dormancy and seven species demonstrating seed dormancy. *E. inflexa* was the sole species to provide data for all the variables sought in the study (Table 1).

A total of 12 abundant species from open wetlands in the Cerrado were traded in 2023. Nine species were traded at Verde Novo and nine at the Rede de Sementes do Cerrado. Most of these species belonged to the Poaceae family. Only *Mauritia flexuosa* was recorded for the Rede de Sementes do Xingu (Table 2). From this list, the species *A. bicornis, A. leucostachyus* and *A. brasilienses* have germination data, but there is a lack of data on seed storage and dormancy. The other species that are marketed lack data on germination, dormancy, storage and seed viability.

Table 2. Abundant herbaceous-shrub species in the 33 wetland sites analyzed in this study traded in the year of 2023.

Espécies	*Rede de Sementes do Cerrado*	*Verde Novo*
Andropogon bicornis	X	X
Andropogon leucostachyus	X	X
Andropogon virgatus		X
Axonopus brasiliensis		X
Echinolaena inflexa	X	X
Lagenocarpus rigidus	X	X
Rhynchospora consaguinea		X
Schizachyrium sanguineum	X	X
Trachypogon spicatus	X	X

Loudetiopsis chrysothrix	X
Rhynchospora consanguinea	X
Hyparrhenia bracteata	X

The *P. gardnerianum* and *Echinolaena inflexa* species, as documented in the referenced studies, demonstrated a gradual increase in germination rate over a 12-month period following seed storage, with germination rates ranging from 0% to 35% and 0% to 43%, respectively. Data on seeds that tolerate storage for up to 12 months were found for the species *Andropogon leucostachyus, Andropogon virgatus, Setaria parviflora, Tristachya leiostachya,* which exhibited germination values between 0% and 25%. In contrast, the species *Andropogon lateralis, Axonopus brasiliensis, P. gardnerianum* demonstrated germination rates between 25% and 55%. The species *Loudetiopsis chrysothrix* and *P. trichostomum* exhibited germination values exceeding 55% following storage.

However, there is currently no data available on their germination. Of the 35 herbaceous-shrub species that are abundant in wetlands, 11 present germination data in this literature review. This finding demonstrates the need to expand research and collection of species for restoration in the region and provides a way to prioritize building knowledge of the germination of these species.

A total of 192 herbaceous-shrub species were surveyed in the studies, and none of these species are part of the RAS. However, 24 of their genera are mentioned in the document. In the National Register of Cultivars (RNC), only forest species native to the Cerrado are registered. In the group of forage species, only 39 species are recorded in the RNC. None of these are native to the Cerrado, and no herbaceous-shrub species from open wetlands were recorded.

Discussion

To date, studies have been conducted on the germination of less than 25% of the most abundant species that structure the plant communities of open wetlands in the Cerrado. It is imperative to gain a deeper understanding of the biology of seeds, particularly those belonging to the Poaceae, Cyperaceae, Asteraceae, and Xyridaceae families, because they are families that are more representative of the Cerrado open wetlands. These families are not only highly abundant in wetlands but also exhibit high levels of endemism, representing 20% of the total flora in the Cerrado (Flora e Funga do Brasil 2024). These graminoid families are significant for the functioning of the hydrological cycles that exist in the open wetlands of the Cerrado.

They facilitate water infiltration through their root structures, which promote soil porosity (Fischer et al. 2015).

The floristic sharing of abundant herbaceous-shrub vegetation between the open wetlands is relatively low. This pattern has also been observed when comparing the entire plant communities between different sites in Cerrado open wetlands. Many species have been recorded in only a few areas, and many of them are endemic (Silva et al. 2017; Bijos et al. 2023). This underscores the necessity of conserving these regions, as they exhibit distinctive local environmental conditions that influence their floristic composition. The lack of evaluation of the germination of these species represents a significant knowledge gap, which makes it challenging to ascertain the extent of their germination success. The discrepancies in germination rates observed for the same species in the reviewed studies indicate that germination can be influenced by the abiotic attributes of the collection sites, in addition to variations in the germination methods and treatments employed (Sales et al. 2013; Kolb et al. 2016; Ribeiro et al. 2021).

It has been demonstrated that species native to the Cerrado, belonging to the Poaceae family, exhibit considerable potential for restoration (Schmidt et al. 2019). This is due to several characteristics, including fast growth, high germination rates, and high seed production (Ramos et al. 2017). These attributes align with the desired characteristics of species employed in the initial phase of restoration, particularly in the early stages of succession (Pereira et al. 2021; Souza et al. 2022). The identification of species about germination time is important for the selection of species with the potential to rapidly occupy the soil, which is a significant attribute for ecological restoration. This enables the exposed soil to be covered and facilitates the control of invasive species, as well as the preparation of the site for the establishment of new species (Martins et al. 2001). In this regard, the species exhibiting the shortest germination times were *Andropogon bicornis, Paspalum trichostomum, Andropogon selloanus,* and *Paspalum gardnerianum.*

The studies revealed a dearth of information pertaining to the dormancy of wetland herbaceous-shrub vegetation. While it is not common to assess the dormancy of native species, we have observed that dormancy is related to seed dispersal. Whether seeds are dormant or not is related to the ecological comprehension of the seedling emergence strategies of these species (Ramos et al., 2017; Escobar et al. 2018). An understanding of dormancy can assist in the decision-making process regarding the storage of species, as dormant seeds are more resistant to storage conditions and can maintain viability for extended periods (Baskin & Baskin 2001;

Escobar et al. 2018; Ramos et al. 2017; Frischie et al. 2020). In the field, many species maintain seed dormancy during the dry season to synchronize germination with the onset of the next rainy season (Giles et al. 2022; Silva et al. 2022). Some evaluated species demonstrated viability after storage. Nevertheless, the loss of viability in the seeds of certain wetland species following prolonged storage (exceeding 12 months) underscores the necessity for sowing these species at the onset of the wet season, after the dry season. In open Cerrado areas, seed dispersal of herbaceous-shrub species occurs predominantly at the end of the rainy season (Batalha & Martins 2004; Munhoz & Felfili 2005), which suggests that many of them will have to remain dormant until the next rainy season, which can take at least four months. Many grass seeds exhibit physiological dormancy following dispersal, which can be overcome through storage (Ramos et al. 2017

Most data available on the germination of open wetland species have been obtained in laboratory settings, with a paucity of information on germination in field conditions. Laboratory assessments of seed germination provide valuable insight into the potential for species germination in the field. The laboratory germination results show that the seeds have a high germination potential in controlled environments. Nevertheless, the discrepancies observed in the germination of species even in a controlled laboratory setting underscore the necessity for the implementation of more authentic field experiments on the germination of Cerrado seeds (Aires et al. 2014; Kolb et al. 2016; Souza et al. 2022). The environmental conditions under which seeds are introduced to restoration in the field differ from those in laboratories. Consequently, it would be prudent to ascertain the biological knowledge of herbaceous-shrub vegetation to enable the adjustment of seed quantities to facilitate their establishment in the field. Field experiments provide tangible insights into the factors that influence species germination. However, the absence of this knowledge can result in management costs or the failure of seedling establishment, ultimately leading to the failure of ecological restoration. Understanding that the seeds of Cerrado open wetland species are a scarce resource and that there is a diversity of species that have other forms of reproduction and propagation, other than seeds, which can be studied and used in ecological restoration.

The collection of native herbaceous-shrub vegetation for restoration has undoubtedly increased in the last decade (Urzedo et al. 2020). However, as observed for the year 2023, the quantity of wetland herbaceous-shrub species still needs to be boosted. The number of seeds of native species abundant in wetlands available for sale (12 species) in November 2023, the beginning of the seed sowing season for restoration, represents only 6.25% of these species. A total of 35 abundant species were recorded in the four wetland sites evaluated in the Chapada dos Veadeiros region, which is the main site for seed collection for ecological restoration in the Cerrado (Montenegro et al. 2024). Of these, 11 species have germination data. However, the availability of species from the region on the seed market is low, with only four species currently available. This result is particularly challenging, as many of these species also occur in Cerrado vegetation types under well-drained soil (Silva et al. 2017), showing their broad importance. It is imperative to enhance the availability of abundant native herbaceous-shrub species with rapid growth and rapid soil occupation, as well as those that are not abundant, to prevent the homogenization of plant communities in the wetlands of the Cerrado. Large-scale sampling of wetlands in the Cerrado has recorded 560 species (Bijos et al. 2023), a significantly higher number than the 192 abundant species surveyed here, further underscoring the need to collect more species, and protect wetlands.

A limited number of species native to the Cerrado have protocols described in the RAS and other normative documents. Furthermore, for wetland species, there is information only at the genus level. It is recommended that public policies aimed at research to analyze minimum quality criteria and seed germination data be encouraged (Celentano et al. 2023). As the commercialization of native seeds continues to expand, to know these initial parameters play a crucial role in the certification process and the recognition of native species seed commercialization activities. This ensures the quality of the seeds and guarantees that buyers can purchase a safe product (Frischie et al. 2020). It is imperative to comply with the relevant legislation and conventions protecting wetlands, given the dearth of studies on the reproduction and establishment of their species (Durigan et al., 2022). It is also imperative to reinforce the conservation of wetlands, as they serve as vital repositories for native seeds, facilitating research and restoration initiatives. Moreover, they act as living laboratories, enabling the study of their functioning and ecological services (Dudley et al., 2020). The acquisition of data on the native species of the Cerrado is crucial for assertive decision-making in the context of conservation and the ecological restoration of the biome.

Conclusion

The abundant species that constitute the structural elements of the open wetlands of the Cerrado demonstrate a pattern of spatial variation in their distribution. There is a paucity of information on the germination of herbaceous-shrub vegetation from open wetlands in the

Cerrado, given the considerable diversity that exists within the Cerrado biome. Further research is required to expand our understanding of germination rates, viability, dormancy, and storage of wetland seeds. Field experiments should be conducted to demonstrate the germination responses of species in real environmental conditions, including those affected by degradation and the environmental conditions of the Cerrado biome. The lack of studies and species for seed marketing represents a significant threat to the restoration of these areas.

The information compiled on the germination and ecological characteristics of the abundant species can be a subsidy for restoration ecology in savannas and understanding the establishment of seedlings in open wetlands. The species have ecological characteristics specific to their localities. The results show that germination in the field is low, so conservation of the areas is a strategy, as is thinking about other forms of reproduction for species native to open wetlands.

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Supporting information

Table S1. Articles consulted with abundance and germination data.

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Table S2. 192 abundant species, surveyed in the literature review, with the number of the article where the information was collected and the vegetation type. V = *vereda*, CLU = *campo limpo úmido*, CSU = *campo sujo úmido*.

Species	**Family**	**Article number**	**Vegetation type**	**Sites**
Achyrocline alata	Asteraceae	2	V	DF3
Agenium leptocladum (Hack.) Clayton	Poaceae	2	V	GO5
Agenium villosum Pilg.	Poaceae	2	V	TO3
Ageratum fastigiatum (Gardner) R.M.King & H.Rob.	Asteraceae	5	V	MG3
Andropogon bicornis	Poaceae	1,2,4,5,9	V, CSU, CLU	DF, DF3, GO2, GO, MG4, SP
Andropogon hypogynus Hack.	Poaceae	2, 10	V, CLU	MG2, DF
Andropogon lateralis	Poaceae	1, 2	V, CLU	DF, DF3, MT1, MT2, MT3, TO3, DF2
Andropogon leucostachyus	Poaceae	2, 10	V	DF3, DF4, GO5, MT2, MT3, DF, GO7
Andropogon selloanus (Hack.) Hack.	Poaceae	5, 10	V, CLU	MG4, DF

Species	Family	Article number	Vegetation type	Sites
Andropogon ternatus	Poaceae	5	V	MG3, MG4
Andropogon virgatus	Poaceae	1, 2, 4, 5, 6, 10	V, CLU	DF, DF3, DF4, GO1, GO3, GO4, GO5, MG2, TO1, GO1 MG4, GO, DF2
Anthaenantiopsis trachystachya	Poaceae	5	V	MG3, MG4
Aristida capillacea	Poaceae	2, 6	V, CLU	GO3, GO5, GO
Arthropogon villosus	Poaceae	2	V	GO1
Axonopus brasiliensis	Poaceae	2	V	DF4, GO6, DF2, GO7
Axonopus comans	Poaceae	1,2	V, CLU	DF, DF1, MG1
Axonopus pellitus	Poaceae	2	V	DF3, GO4, TO3
Bulbostylis hirtella	Cyperaceae	5	V	MG4
Bulbostylis jacobinae	Cyperaceae	2	V	GO5
Bulbostylis paradoxa	Cyperaceae	2	V	GO5
Bulbostylis sellowiana	Cyperaceae	2,4	V	DF4, GO4, GO
Burmannia bicolor	Burmanniaceae	2	V	GO4
Calyptrocarya glomerulata	Cyperaceae	2	V	GO5
Cambessedesia hilariana	Melastomataceae	2	V	GO4

Species	Family	Article number	Vegetation type	Sites
Cantinoa carpinifolia	Lamiaceae	1	CLU	DF
Cantinoa subrotunda	Lamiaceae	2	V	GO5, MT2
Cephalostemon riedelianus	Rapateaceae	2	V	MG1
Chaetogastra gracilis	Melastomataceae	5	V	MG4
Chamaecrista desvauxii	Fabaceae	2	V	GO4, MG2
Chamaecrista desvauxii var. chapadicola	Fabaceae	3	CLU	PI
Chamaecrista nictitans	Fabaceae	2	V	GO5
Chromolaena vindex	Asteraceae	1,2	V, CLU	DF, GO5
Cissus spinosa	Vitaceae	2	V	GO4
Comanthera xeranthemoides	Eriocaulaceae	2	V	MG1, TO1
Cuphea antisyphilitica	Lythraceae	2	V	TO1, TO2, TO4
Cuphea spermacoce	Lythraceae	2	V	GO5
Curtia tenuifolia	Gentianaceae	2	V	GO4
Cuscuta partita	Lauraceae	3	CLU	PI

Species	**Family**	**Article number**	**Vegetation type**	**Sites**
Cyperus brasiliensis	Cyperaceae	5	V	MG4
Cyperus haspan	Cyperaceae	4	V	GO
Cyperus rigens	Cyperaceae	2	V	GO5
Cyperus sesquiflorus	Cyperaceae	5	V	MG4
Desmocelis villosa	Melastomataceae	10	CLU	DF
Dicranopteris flexuosa	Gleicheniaceae	5	V	MG4
Dioscorea amaranthoides	Dioscoreaceae	2	V	GO5
Echinocoryne holosericea	Asteraceae	2	V	GO4
Echinolaena inflexa	Poaceae	1,2,4,5,6, 10	V, CLU	DF, DF3, GO5, GO, MG3, MG4, GO, DF, DF2
Eleocharis capillacea	Cyperaceae	4	V	GO
Elephantopus hirtiflorus	Asteraceae	3	CLU	PI
Eriocaulon humboldtii	Eriocaulaceae	2	V	GO7
Eriocaulon linearifolium	Eriocaulaceae	4	V	GO
Eriocaulon modestum	Eriocaulaceae	2	V	BA

Species	Family	Article number	Vegetation type	Sites
Eriocaulon sellowianum	Eriocaulaceae	2	V	GO5
Eriochrysis cayennensis	Eriocaulaceae	4, 5	V	GO, MG4
Froelichiella grisea	Amaranthaceae	6	CLU	GO
Gaylussacia brasiliensis	Ericaceae	10	V	DF
Hildaea pallens	Poaceae	2	V	GO4
Hyparrhenia bracteata	Poaceae	5	V	MG3, MG4
Hypogynium virgatum	Poaceae	10	V	DF
Hyptis campetris	Lamiaceae	10	V	DF
Hyptis crenata	Lamiaceae	2	V	MT2
Hyptis linarioides	Lamiaceae	2	V	TO3
Ipomoea procurrens	Convolvulaceae	2	V	GO5
Juncus effusus	Juncaceae	2	V	TO1
Justicia sericographis	Acanthaceae	2	V	GO4
Lagenocarpus rigidus	Cyperaceae	1, 2, 6	V, CLU	DF, BA, DF1, DF4, GO3, TO1, TO2, TO3, TO4, GO

Species	**Family**	**Article number**	**Vegetation type**	**Sites**
Lavoisiera imbricata	Melastomataceae	2, 10	V, CLU	DF, DF3
Leiothrix crassifolia	Eriocaulaceae	2	V	MG1
Lippia rotundifolia	Verbenaceae	2	V	GO5
Loudetia flammida	Poaceae	5	V	MG3, MG4
Loudetiopsis chrysothrix	Poaceae	5, 6	V, CLU	MG3, GO
Ludwigia nervosa	Onagraceae	4	V	GO
Lycopodiella alopecuroides	Lycopodiaceae	10	CLU	DF
Macairea radula	Melastomataceae	2	V	GO7
Mayaca sellowiana	Mayacaceae	9	CLU	SP
Mesosetum elytrochaetum	Poaceae	6	CLU	GO
Mesosetum loliiforme	Poaceae	2, 3	V, CLU	GO3, GO5, PI
Mesosetum penicillatum	Poaceae	2	V	GO4
Miconia chamissois	Melastomataceae	4, 5, 10	V	GO, MG4, DF
Microlicia euphorbioides	Melastomataceae	4	V	GO

Species	Family	Article number	Vegetation type	Sites
Microlicia helvola	Melastomataceae	4	V	GO
Microlicia hirsuta	Melastomataceae	10	V	DF
Microlicia insignis	Melastomataceae	2	V	MT2
Microlicia viminalis	Melastomataceae	6	CLU	GO
Mikania officinalis	Asteraceae	1	CLU	DF
Mimosa hypoglauca	Fabaceae	3	CLU	PI
Mimosa sensitiva	Fabaceae	2	V	GO4
Oedochloa camporum	Poaceae	2	V	MT1, MT2, MT3
Oedochloa procurrens	Poaceae	2, 5	V	GO2, GO4, GO5, MG3, DF2
Otachyrium seminudum	Poaceae	2, 4	V	GO, GO4
Otachyrium versicolor	Poaceae	2	V	BA
Paepalanthus elongatus	Eriocaulaceae	2	V	GO4, GO5
Paepalanthus flaccidus	Eriocaulaceae	2	V	GO5, GO7

Species	Family	Article number	Vegetation type	Sites
Paepalanthus scandens	Eriocaulaceae	10	V	DF
Paepalanthus trichophyllus	Eriocaulaceae	10	CLU	DF
Palhinhaea cernua	Lycopodiaceae	11	CLU	DF
Panicum campestre	Poaceae	2	V	TO2
Panicum cervicatum	Poaceae	2, 10	V, CLU	DF, GO5
Paspalum cordatum	Poaceae	5	V	MG3, MG4
Paspalum dedeccae	Poaceae	2	V	DF3, GO4, TO1, TO2, TO3, TO4, DF2
Paspalum ellipticum	Poaceae	2	V	DF4
Paspalum erianthum	Poaceae	10	V, CLU	DF
Paspalum gardnerianum	Poaceae	2	V	GO5, MT2, MT3
Paspalum geminiflorum	Poaceae	2	V	DF1
Paspalum glaucescens	Poaceae	2	V	DF3, GO5
Paspalum hyalinum	Poaceae	2	V	GO5, TO3
Paspalum lineare	Poaceae	1, 2, 6	V, CLU	DF, BA, DF1, DF3, DF4, GO1, GO2, GO3, GO4, GO5,

Species	Family	Article number	Vegetation type	Sites
				GO6, MG2, MG1, MT1, MT2, TO2, TO3, TO4, GO, DF2
Paspalum maculosum	Poaceae	2, 10	V, CLU	GO5, GO6, MG2, DF
Paspalum multicaule	Poaceae	2, 3, 9	V, CLU	GO5, PI, SP
Paspalum polyphyllum	Poaceae	1	CLU	DF
Paspalum scalare	Poaceae	6	CLU	GO
Paspalum trichostomum	Poaceae	2	V	GO2, MG2
Pfaffia jubata	Amaranthaceae	1	CLU	DF
Piper aduncum	Piperaceae	4	V	GO
Polygala celosioides	Polygalaceae	2	V	GO4
Pseudotrimezia juncifolia	Iridaceae	2	V	GO5
Psychotria anceps	Rubiaceae	4	V	GO
Raulinoreitzia tremula	Asteraceae	4	V	GO
Rhynchanthera grandiflora	Melastomataceae	3,4	V, CLU	PI, GO
Rhynchospora albiceps	Cyperaceae	2, 10	V, CLU	GO5, DF

Species	Family	Article number	Vegetation type	Sites
Rhynchospora barbata	Cyperaceae	2, 3	V, CLU	TO3, PI
Rhynchospora confinis	Cyperaceae	2	V	MT3
Rhynchospora consanguinea	Cyperaceae	2,4	V	DF4, GO3, TO2, GO
Rhynchospora emaciata	Cyperaceae	2,6	V, CLU	GO3, TO1, GO, DF2, GO7
Rhynchospora globosa	Cyperaceae	2,4, 8, 10	V, CLU	DF4, GO1, GO2, GO3, GO4, GO5, MG1, MT1, MT2, MT3, TO1, TO2, TO3, TO4, GO, DF, DF2, GO7
Rhynchospora hirta	Cyperaceae	2	V	TO1
Rhynchospora marisculus	Cyperaceae	2	V	DF4
Rhynchospora riparia	Cyperaceae	3	CLU	PI
Rhynchospora robusta	Cyperaceae	2, 4, 6	V, CLU	GO5, GO
Rhynchospora rugosa	Cyperaceae	1,2, 9	V, CLU	DF, DF3, DF4, SP
Rhynchospora spruceana	Cyperaceae	2, 6	V, CLU	GO1, GO2, GO4, GO

Species	Family	Article number	Vegetation type	Sites
Rhynchospora tenerrima	Cyperaceae	6	CLU	GO
Rhynchospora tenuis	Cyperaceae	2,4, 10	V, CLU	DF1, DF3, DF4, GO4, GO5, MG1, MT1, MT2, MT3, GO, DF, GO7
Rhynchospora velutina	Cyperaceae	5	V	MG4
Riencourtia oblongifolia	Asteraceae	2	V	GO5
Saccharum angustifolium	Poaceae	4	V	GO
Saccharum asperum	Poaceae	5, 10	V, CLU	MG3, DF
Sauvagesia linearifolia	Ochnaceae	2	V	GO4
Sauvagesia racemosa	Ochnaceae	4	V	GO
Schizachyrium condensatum	Poaceae	2, 10	V,CLU	DF4, DF
Schizachyrium sanguineum	Poaceae	2	V	DF2
Schizachyrium tenerum	Poaceae	5, 8, 10	V, CLU	MG3, MG4, GO, DF
Schultesia guianensis	Gentianaceae	2	V	GO5

Species	**Family**	**Article number**	**Vegetation type**	**Sites**
Scleria hirtella	Cyperaceae	6	CLU	GO
Scleria distans	Cyperaceae	4	V	GO
Scleria leptostachya	Cyperaceae	2, 6	V, CLU	DF4, GO3, GO4, GO5, GO
Setaria parviflora	Poaceae	5	V	MG4
Setaria paucifolia	Poaceae	10	V, CLU	DF
Sinningia elatior	Gesneriaceae	2	V	GO5
Siphanthera subtilis	Melastomataceae	2	V	GO5
Sisyrinchium vaginatum	Iridaceae	8, 10	CLU	GO, DF
Sphagnum sp1	Shagnaceae	2	V	GO7
Sporobolus pyramidatus	Poaceae	2	V	GO2
Steinchisma decipiens	Poaceae	4	V	GO
Steinchisma laxum	Poaceae	9	CLU	SP
Steirachne barbata	Poaceae	3	CLU	PI
Stylosanthes angustifolia	Fabaceae	3	CLU	PI
Symplocos nitens	Symplocaceae	10	CLU	DF
Syngonanthus anthemiflorus	Eriocaulaceae	4	V	GO

Species	Family	Article number	Vegetation type	Sites
Syngonanthus caulescens	Eriocaulaceae	4	V	GO
Syngonanthus decorus	Eriocaulaceae	6	CLU	GO
Syngonanthus densiflorus	Eriocaulaceae	2, 4, 10	V	GO5, GO, DF, GO7
Syngonanthus fischerianus	Eriocaulaceae	2	V	TO1, DF2
Syngonanthus gracilis	Eriocaulaceae	2, 6	V, CLU	GO5, GO
Syngonanthus nitens	Eriocaulaceae	2	V	TO2
Syngonanthus xeranthemoides	Eriocaulaceae	8	CLU	GO
Tococa guianensis	Melastomataceae	10	CLU	DF
Trachypogon spicatus	Poaceae	2, 3, 6, 9, 10	V, CLU	BA, GO3, GO5, MG2, MT2, MT3, TO1, TO2, TO3, TO4, PI, GO, SP, DF, GO7
Trembleya phlogiformis	Melastomataceae	2, 10	V, CLU	DF1, DF3, DF

Species	Family	Article number	Vegetation type	Sites
Trichanthecium cyanescens	Poaceae	4, 10	V. CLU	GO, DF
Trichanthecium parvifolium	Poaceae	6	CLU	GO
Trichanthecium wettsteinii	Poaceae	2	V	GO5, MG2
Tristachya leiostachya	Poaceae	2	V	DF2
Urospatha sagittifolia	Araceae	2	V	DF3, GO5
Utricularia triloba	Lentibulariaceae	4	V	GO
Vellozia pumila	Velloziaceae	2, 6	V, CLU	GO2, GO4, GO5, MG3, DF2
Xanthosoma striatipes	Araceae	4	V	GO
Xyris blanchetiana	Xyridaceae	2	V	GO4, GO5
Xyris ciliata	Xyridaceae	6	CLU	GO
Xyris fallax	Xyridaceae	2	V	GO4
Xyris guaranitica	Xyridaceae	2	V	DF2
Xyris hymenachne	Xyridaceae	2	V	TO4
Xyris jupicai	Xyridaceae	3	CLU	PI
Xyris macrocephala	Xyridaceae	4, 2, 10	V	GO, DF, DF2
Xyris savanensis	Xyridaceae	2, 3	V,CLU	GO4, TO2, PI

Species	**Family**	**Article number**	**Vegetation type**	**Sites**
Xyris schizachne	Xyridaceae	2	V	DF2
Xyris seubertii	Xyridaceae	9	CLU	SP
Xyris tenella	Xyridaceae	10	V	DF
Xyris tortula	Xyridaceae	6	CLU	GO
Zornia latifolia	Fabaceae	5	V	MG4